Remarks

The Examiner has maintained his rejection of claims 1, 3, 4, 8-14, 35, 36, 48, 50, 56, 58 and 66-68. Claims 1, 9, 35, 48, 66 and 67 have been amended. New claims 69-73 have been added. These amendments are believed to introduce no new matter, and their entry is respectfully requested. Support for these amendments can be found throughout the specification, and in particular on pages 69-72. Based on the above amendment and the following remarks, Applicants respectfully request that the Examiner reconsider all outstanding rejections and that they be withdrawn.

A. Response to Rejections Under 35 U.S.C. § 103

Claims 1, 3-4, 8-14, 35-36, 48, 50, 56, 58, 66-68 were rejected as obvious based on the combination of Takagi *et al.* ("Redundant CORDIC methods with a constant scale factor for Sine and Cosine computation") in view of Fox *et al.* (U.S. Patent 5,276,633). This rejection is respectfully traversed, and reconsideration is requested based on the following remarks.

1. Discussion of Takagi and Fox

The Takagi article concerns a CORDIC method of computing $\sin\theta$ and $\cos\theta$, given θ. CORDIC can be extended to do many other things and, over the past half-century, it has been so extended by countless authors. Nonetheless, this Takagi article addresses only the basic CORDIC computation of $\sin\theta$ and $\cos\theta$. The Takagi CORDIC system is not an angle rotator. In contrast, the claimed invention, an angle rotator, starts with an input (complex number) that is an arbitrary point (X_0, Y_0) in the X-Y plane and an angle θ, and it rotates the point (X_0, Y_0) counterclockwise (that is, rotates it counterclockwise about the origin), through the angle θ (radians) to arrive at a point

(X_2, Y_2) in the plane, which becomes the system's output. Thus, the input (X_0, Y_0) can be one of a plethora of points in the plane.

The Fox et al. patent concerns a circuit for accepting the (radian) value of a system input angle θ and computing the two system output values $\sin\theta$ and $\cos\theta$. This is, of course, the same objective as the Takagi CORDIC circuit. The Fox invention, however, does not use the CORDIC method of computing $\sin\theta$ and $\cos\theta$. The Fox circuit requires that the value of the input angle θ be provided as two separate parts, a coarse angle value A and a fine angle value B. That is, the Fox circuit has two inputs A and B and these inputs satisfy $A + B = \theta$. Moreover, A is a representation of the coarse part of θ and B is a representation of the fine part of θ. (Given a binary representation of θ, the most significant bits of θ could define A and the least significant bits of θ could define B.)

The Fox circuit employs memories in which values of $\sin A$ and $\cos A$ are stored and retrieved for a certain range of values of the system input angle A. It also has other memories in which values of $\sin B$ and $\cos B$ are stored and retrieved for a certain range of values of the system input angle B. Furthermore, the Fox circuit employs computational circuitry wherein the system outputs $\sin\theta = \sin(A+B)$ and $\cos\theta = \cos(A+B)$ are computed. The values of $\sin A$, $\cos A$, $\sin B$, and $\cos B$, obtained from the memories, are used to compute the output values $\sin\theta$ and $\cos\theta$ via the well-known trigonometric identities for the sine and cosine of the sum of two angles, namely:

$$\begin{aligned}\sin(A+B) &= \sin(A)\cos(B) + \cos(A)\sin(B)\\ \cos(A+B) &= \cos(A)\cos(B) - \sin(A)\sin(B).\end{aligned} \tag{1}$$

The Fox patent is primarily focused on various novel aspects of the implementation of this simple system, aspects such as certain ROM compression techniques to minimize ROM storage requirements, and the use of efficient methods of implementing the four multiplications that are inherent in the sum-of-angles formulas (1).

2. *Angle Rotation*

An angle rotator is related to the trigonometric functions $\sin\theta$ and $\cos\theta$ as follows. By using a famous result in mathematics called the "Givens rotation" that treats the (X, Y) points in the plane as vectors, it is known that the input pair (X_0, Y_0) is related to the (rotated) output pair (X_2, Y_2) by the following matrix-vector equation involving $\sin\theta$ and $\cos\theta$:

$$\begin{pmatrix} X_2 \\ Y_2 \end{pmatrix} = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}. \tag{2}$$

Another useful point-of view considers the X-Y plane to be the complex plane. Thus, X_0 is the real part and Y_0 is the imaginary part of an input complex number $X_0 + jY_0$. In this sense, the angle rotator simply produces a multiplication of two complex numbers, yielding an output complex-number, as follows:

$$(X_2 + j\, Y_2) = (\cos\theta + j\sin\theta)(\, X_0 + j\, Y_0).$$

It is trivial to show that this relation is equivalent to the computations indicated in equation (1). And, since $\cos\theta + j\sin\theta = e^{j\theta} = 1\angle\theta$, it is evident that this multiplication by the (magnitude = 1) complex number $1\angle\theta$ simply adds the angle θ to the angle of the

input complex number $X_0 + j\, Y_0$ (i.e., rotates it by the angle θ) to get the output complex number $X_2 + j\, Y_2$.

The claimed invention rotates an angle based on equation (2) by constructing the matrix equation in two stages. That is, it performs the rotation in a coarse rotation stage to map (X_0, Y_0) to an intermediate point (X_1, Y_1) and then it employs a fine rotation stage where it maps the intermediate point (X_1, Y_1) to the point (X_2, Y_2). In terms of the mathematics, the claimed invention implements two equations (each being a version of the above equation (2)):

$$\begin{pmatrix} X_2 \\ Y_2 \end{pmatrix} = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 \\ \sin\theta_2 & \cos\theta_2 \end{bmatrix} \begin{pmatrix} X_1 \\ Y_1 \end{pmatrix}, \qquad \begin{pmatrix} X_1 \\ Y_1 \end{pmatrix} = \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix} \begin{pmatrix} X_0 \\ Y_0 \end{pmatrix}$$

where the angle θ has been broken into two parts, $\theta = \theta_1 + \theta_2$ (note that a slightly different notation appears in the patent specification.). This effectively implements the Givens rotation matrix as a product of two matrices:

$$\begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} = \begin{bmatrix} \cos\theta_2 & -\sin\theta_2 \\ \sin\theta_2 & \cos\theta_2 \end{bmatrix} \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix}.$$

3. ***The Claimed Invention is not Taught or Suggested by Takagi or Fox***

The claimed invention is fundamentally different from Takagi CORDIC and Fox in a number of ways.

The claimed invention recites an angle rotator. As such it accommodates an arbitrary starting input point (X_0, Y_0) in the X-Y plane and rotates it by a specified angle θ. Thus, the claimed invention has three inputs for each rotation performed: two numbers specify the values of the coordinates of a starting point (X_0, Y_0) in the X-Y plane,

a third number specifies the value of the angle θ through which the point (X_0, Y_0) is to be rotated. The Takagi system always starts at a fixed point (K, 0) (internal to the system) in the X-Y plane and rotates it by a specified angle θ. Fox retrieves coarse and fine sine and cosine values from ROM tables and then performs the straightforward multiplications and additions that implement the sum-of-two-angles formulas given in equation (1) above.

Applicants have amended independent claims 1, 9 and 35 to make clear that the angle rotator starts with any arbitrary complex number not merely a fixed number starting point. Thus the input of the claimed invention can be any complex number (X_0, Y_0) in the X-Y plane, which is impossible in the system of Takagi and Fox. Importantly, this amendment is not being made to overcome the rejection, but rather to more accurately recite the invention. Provided below are additional reasons why the claimed invention is patentable over the cited art.

The claimed invention also recites a memory that stores the value of trigonometric functions of certain angles. More precisely, the trigonometric function values $\sin\theta_M$ and $\cos\theta_M$ are stored for a set of angles θ_M that span the range of system-input values θ to be encountered, during operation. These values are not stored by Takagi or Fox. The Takagi CORDIC circuit determines in advance, and stores in a memory within the CORDIC circuit, the value of certain angles. More precisely, the Takagi CORDIC circuit stores the (radian) values of the n (small) angles θ_k = arctan 2^{-k}, for $k = 1, \ldots, n$. Neither Takagi nor Fox uses fine adjustment values as recited in Applicant's claims.

The claimed invention uses the value of the angle θ to choose the sine and cosine values of a related angle θ_M. Thus, the trigonometric functions used in the claimed invention are sines and cosines. The Takagi CORDIC circuit does not choose from a memory a $\sin\theta_M$ or $\cos\theta_M$ value for a related angle θ_M by using the value of its system input angle θ. The trigonometric functions used in the Takagi CORDIC circuit are tangents. It is important to notice that the Takagi circuit uses no sines and/or cosines (of *any* angles).

Lastly, but by no means least important, Takagi and Fox ***cannot*** be combined to create the claimed invention. Since the Takagi CORDIC circuit performs its computations by using only one trigonometric function, the *tangent*, and since the Fox patent performs its computations by using different trigonometric functions, *sines* and *cosines*, it is evident that the combination of Takagi and Fox would be pointless, if not impossible. Certainly it would not be evident to one having ordinary skill in the art that a combination of these two systems, or the use of key features of one of these systems within the other system, would be possible and would serve a useful purpose. The Examiner is specifically request to present an argument as to how these two systems could be combined given the different types of trigonometric functions used by Takagi and Fox should the rejection be maintained.

Further, there is absolutely no motivation to combine Takagi and Fox. In order to establish a prima facie case of obviousness, "there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings." MPEP §2142. Instead of providing evidence of a suggestion or motivation

to combine the references in support of the rejection, the Examiner simply concludes that it would be "obvious to a person having ordinary skill in the art at the time of the invention is make to add a lacking feature in primary reference from secondary reference because obviously it would enable to increase the system performance by pre-calculating and storing the values for rotating at a desire angle (col. 2 lines 33-43)." However, the motivation must be found within the prior art documents. "Broad conclusory statements standing alone are not 'evidence'." *Id.* Applicants assert that the conclusory statement of the Office Action (cited above) does not provide sufficient objective evidence of a suggestion of the desirability of doing what Applicants have claimed. M.P.E.P § 2143 provides guidance to Examiners in meeting this burden:

> The initial burden is on the examiner to provide some suggestion of the desirability of doing what the inventor has done. "To support the conclusion that the claimed invention is directed to obvious subject matter, either the references must expressly or impliedly suggest the claimed invention or the examiner must present a convincing line of reasoning as to why the artisan would have found the claimed invention to have been obvious in light of the teachings of the references." *Ex parte Clapp*, 227 USPQ 972, 973 (Bd. Pat. App. & Inter. 1985).

Applicants assert that such objective evidence of a suggestion or motivation has not been provided. Applicants also note "it is impermissible to use the claimed invention as an instruction manual or 'template' to piece together the teachings of the prior art so that the claimed invention is rendered obvious . . . ." *In re Fritch*, 972 F.2d 1260 (Fed. Cir. 1992). Thus, Applicants respectfully request that objective evidence of a suggestion be provided, presenting a convincing line of reasoning, or that the claims be passed to allowance.

One or more of the arguments presented above apply to each of the independent claims 1, 9, and 35. Accordingly, the rejected independent claims are patentable over the

cited art. Also, Applicants respectfully submit that dependent claims 3, 4, 8, 10-14, 36 and 66-68, are also patentable over Takagi and Fox since they depend on claims 1, 9 and 35, respectively.

Additionally, independent claims 48, 50, and 58 recite, *inter alia*, means for generating a fine adjustment value and claim 56 recites the step of generating a fine adjustment value. These elements and/or steps are not taught or suggested by Takagi or Fox. The Examiner asserts that there is "a fine adjustment circuit (step 3 in the left column in page 991)" in the Takagi circuit. This is incorrect. There is no "fine adjustment circuit" in CORDIC that "generates a fine adjustment value." The Office Action does not point out where the "fine adjustment value" is. The transformation the Office Action cites as being performed as Step 3 is not at all correctly characterized as an "adjustment" (fine or otherwise). What is described at Step 3 is a computation that is performed once the CORDIC algorithm is finished and it has generated the desired $\sin\theta$ and $\cos\theta$ values. Takagi's generated $\sin\theta$ and $\cos\theta$ values are, due to the method Takagi espouses, expressed in an unusual format at that point in the process, a so-called "redundant representation." Step 3 simply converts the format of these output sine and cosine numbers into normal binary format. Fox fails to cure the deficiency of Takagi of providing a means for generating a fine adjustment value.

Finally, independent claim 50 also recites "a scaling circuit that scales said coordinate value of said output complex number using said value approximating cos θ_1 to generate the single coordinate output," which is not taught or suggested by Takagi or Fox. Accordingly, Applicants respectfully request that the rejection be withdrawn and claims 1, 3, 4, 8-14, 35, 36, 48, 50, 56, 58 and 66-68 be passed to allowance.

4. *General Comments*

Applicants disagree with many of the arguments made throughout the Office Action, including each point made by the Examiner in his Response to Arguments section. Nevertheless, for the sake of brevity, the undersigned will not respond to each argument. Applicants submit that the remarks above adequately demonstrate that the art cited by the Examiner does not teach or suggest the claimed invention.

Conclusion

All of the stated grounds of rejections have been properly traversed, accommodated, or rendered moot. Applicants therefore respectfully request that the Examiner reconsider all presently outstanding rejections and that they be withdrawn. Applicants believe that a full and complete reply has been made to the outstanding Office Action and, as such, the present application is in condition for allowance. If the Examiner believes, for any reason, that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at the number provided.

Prompt and favorable consideration of this Amendment and Reply is respectfully requested.

Respectfully submitted,

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